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# METHOD AND DEVICE FOR DISPLAYING IMAGES

## Technical Field
The present invention relates to displaying images
on an electronic display.

5       ## Technical Background
A digital image has a particular appearance on a
display. Further, the image is differently perceived by
different individuals. In all, it is therefore not
possible to obtain a general appearance, which is
10     perceived as optimal by every individual. Additionally,
variations in ambient light cause different conditions
from time to time. This problem has been addressed in the
US patent No. 6,094,185, wherein computer display
parameters are automatically adjusted in accordance with
15     user preferences and ambient light. Thus, an individual
is able to input preferred settings of the display, e.g.
as regards brightness or contrast, and the ambient light
is considered. On basis of the personal preferences, and
the present ambient light, a display parameter, such as
20     brightness or contrast is adjusted.
However, this method is far from optimal. One
problem is that when adjusting a single display
parameter, or property, other properties are often
affected as well. In other words, negative resulting
25     effects appear, which will have to be considered in order
to achieve a desired appearance of the image on the
display.

## Summary of the Invention
30     An object of the present invention is to provide a
solution to the problem of said resulting effects when
adjusting a display parameter.
In accordance with a first aspect of the invention,
the object is achieved with a method for improving a

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digital image for displaying an improved image on a
display. The method comprises improving a digital image
for displaying an improved image on a display,
comprising:
5        - determining an instantaneous property of the
display;
         - determining a property of the digital image;
         - determining parameters for an image processing
method at least partly on basis of said instantaneous
10   property of the display, and said property of the digital
image; and
         - processing the digital image by means of said
image processing method, while applying said parameters.
         Consequently, in accordance with the method
15   according to the present invention, the problem of the
resulting effects is basically solved, not by trying to
avoid said resulting effects but by detecting them. When
an (i.e. at least one) instantaneous display property is
determined, the current state of the display is detected.
20   Any changes affecting said property are thus considered
by the method.
         Further, according to the method, the very image is
processed on basis of, inter alia, the instantaneous
display property. It is to be noted that the thus
25   improved image is improved as regards the appearance
thereof on the display in question. Thus, rather than
merely adjusting one or a few properties of the display,
as in the prior art, properties of the very image are
adjusted so as to adapt the image to the display on which
30   it is displayed. The adjustment is performed on an
instantaneous basis, i.e. on basis of said instantaneous
property of the display. In other words, the current
state of the property is determined, as a part of the
image improvement method according to the present
35   invention. Thus, not only static but also dynamic
circumstances are taken into account by the method
according to the invention. The tool for adjusting the

image is an image processing method. The parameters for the method are set in dependence of properties of the original, non-improved image, and of the display.

As defined above, the scope of the method includes
5    the option that several different properties of the image, and/or the display are taken into account. There are several different possible properties that said instantaneous property of the display can be chosen from, including, but not limited to, contrast, brightness,
10   illumination, and color intensity. Some of these can be user-adjustable. Similarly, there are several different possible properties that said property of the image can be chosen from, including, but not limited to, contrast, brightness, sharpness, and contents or type of image,
15   i.e. for example whether the image is imaginary or a photography.

In an embodiment of the method all measures, i.e. determining properties of the display and the image, determining parameters for an image processing method,
20   and processing the digital image are repeated at a repetition rate. This means that the displayed image is adjusted at a determined rate in order to keep it optimised, despite changes in the display conditions appearing over time. The rate can be set such that the
25   method runs continuously in a loop. In other words, the image is then reprocessed repeatedly.

In an embodiment of the method it comprises detecting a change in said instantaneous property of the display; and repeating said determining and processing
30   measures when a change is detected. For example, this embodiment takes care of a situation where some display settings are user-specific, i.e. are adjustable by the user. As soon as a setting is changed by the user this is detected and compensated for, in order to retain the
35   optimal image quality. Another example is a change in the illumination of the display, for example due to an external change, such as when the user passes from

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outdoors to indoors. In an embodiment of the method, the image processing method comprises at least one sub-method chosen from a group of sub-methods consisting of saturation increase, color componentwise histogram
5   stretch, and unsharp masking.

This embodiment is preferred when the display is of a type having a small color gamut. Such displays are typical for applications where a low power consumption is desired. Such applications are typically mobile devices.
10  Typical displays are transflective displays and the like, as will be further discussed below. An advantage of these simple methods is that they have small requirements of processing capacity, and thus they are suitable for mobile applications. Still the image improvement
15  capability of these methods is enough for causing a significant improvement of the quality of the displayed image. To a man skilled in the art, this may seem contradictory, since these simple methods are known to be accompanied with some overcompensating properties, in
20  turn causing undesired effects, as will be further explained below. However, it has turned out that these undesired effects are masked to a sufficient extent by said small color gamut displays, leaving, substantially, merely the image improvements to the eyes of a viewer.
25      In accordance with a second aspect of the invention, the object is achieved with a mobile device comprising a display unit, an image memory for holding a digital image, and an image improvement unit for improving said digital image, which is displayed on the display. The
30  image improvement unit is arranged to process said digital image by means of an image processing method; and to determine parameters for said image processing method at least partly on basis of an instantaneous property of the display, and a property of the digital image.
35      As for the method the appearance of a displayed image is improved in relation to the prior art, since the device improves the very image, and, in doing so, takes

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into account the effect of adjustment on the
instantaneous display property.

In an embodiment of the device according to the
invention, the display is a reflective display or a
5    transflective display. These display choices are
preferred in a mobile unit due to the low power
consumption thereof. As regards the transflective
display, in a basic mode the display is solely
reflective, but when the ambient light is not enough for
10   illuminating the display an internal back-light is
activated and adjusted according to the ambient light. On
the other hand, the color gamuts of the reflective and
transflective displays are limited. However, the present
invention contributes substantially to the image quality
15   and substantially reduces the drawbacks of these types of
displays.

In accordance with a third aspect of the invention,
the object is achieved with a display unit comprising: a
display, an image memory for holding a digital image, and
20   an image improvement unit for improving said digital
image, which is displayed on the display. Said image
improvement unit is arranged to process said digital
image by means of at least one image processing method;
and to determine parameters for said/each image
25   processing method at least partly on the basis of an
instantaneous property of the display, and a property of
the digital image.

In accordance with a fourth aspect of the invention,
the object is achieved with the use of at least one image
30   processing method comprising at least one sub-method
chosen from a group of sub-methods consisting of
saturation increase, color componentwise histogram
stretch, and unsharp masking, for improving a digital
image for display in accordance with the method or mobile
35   device above.


Brief description of the drawings

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Exemplifying embodiments of the invention will be described below with reference to the accompanying drawings, in which:

Fig. 1 illustrates a schematic block diagram of
5    central parts of an embodiment of a mobile device comprising image improvement circuitry, according to the invention;

Fig. 2 illustrates another embodiment of a mobile device; and

10    Fig. 3-5 illustrates different image processing methods.


Description of embodiments

In the following the present invention is explained
15    by means of an aspect where it is implemented in a mobile device. It is to be noted that the invention may as well be implemented in a stationary device.

A mobile device 1, , capable of handling images, according to a preferred embodiment, comprises a display
20    unit 3, a control unit, such as a micro controller (MCU) 5, connected to the display unit 3, and a decoder and an encoder 7 and 9, respectively, for reception and transmission of external images, as shown in Fig. 1. The decoder 7 and the encoder 9 are connected to the micro
25    controller 5.

The display unit 3 comprises a display 11, a display memory 13, connected to the display 11, for holding images which are displayed, a display adjustment unit 15, connected to the display 11, by means of which display
30    properties are adjusted, and a display processor 17, connected to the display memory 13 and to the display adjustment unit 15. In this embodiment the display processor 17 serves as an image improvement unit. Further, the mobile device comprises an ambient light
35    sensor 19, which is connected to the micro controller 5. As is understood to a man skilled in the art, the mobile device comprises many other parts and circuits in

dependence of what type of device it is. However, for reasons of clarity and simplicity, merely those parts which are needed for the disclosure and explanation of the present invention are illustrated. It is an easy task
5   for a skilled man to add general functionality in order to obtain a fully competent device, such as a mobile phone, a PDA device, i.e. a small mobile hand-held device that provides computing and information storage and retrieval capabilities for keeping schedule calendars and
10  address book information handy, a laptop computer, i.e. an all-in-one computer that is easily portable, video glasses or other accessory devices to portable devices, etc.

The image improvement method of the present
15  invention is now to be explained as performed by the device in Fig. 1. An image is received at the mobile device 1 and decoded in the decoder 7. The image is then stored in the display memory 13. Then, the image improvement unit, i.e. the display processor 17,
20  determines a property, or typically several properties, of the image and compares these image properties with one or more properties of the display 11. In all situations where the properties of the image are not already optimised to the display 11, an improvement procedure is
25  initiated. The display processor 17 manipulates the properties of the image, by means of an image processing method, employing at least one sub-method, or algorithm, for example one or more of those mentioned above, in order to improve the appearance of the image on the
30  display 11. The improved image is stored in the display memory 13. Then the improved image is applied to the display 11 from the memory 13.

In a mobile device, a general aim is to minimise the power consumption of the circuitry of the device as well
35  as of the processes run by the circuitry. It is therefore preferred that the display is of a low power type, and preferably is a reflective or transflective LCD display.

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As a contrast CRT displays can be mentioned, which have a
relatively high power consumption. On the other hand, it
has been shown that, at present, reflective and
transflective LCD displays have some insufficient
properties in comparison with, for example, CRT displays.
The color gamuts of the low power displays are relatively
small, and, additionally, they are dependent on the
intensity and quality of the ambient light, and of the
internal light source, which is energised when necessary.
Further, the contrast ratio is quite low. These
deficiencies result in that many images appear to have
low contrast and faint colors. Consequently, preferred
image processing algorithms are those which compensate
for the low color gamut and low contrast ratio. There do
exist advanced algorithms, which can be tailored for a
certain type of display and adapt any image as far as
possible. However, when it comes to a mobile device, the
processing capacity thereof is limited, and so is the
available power. Consequently, it is preferred that the
image processing algorithms are simple and consume little
power. It has proven possible to achieve this while still
achieving a substantial improvement of the perceived
image quality.

One useful image processing sub-method is a
saturation increase algorithm, which increases the
difference between grey and each color component. Thus,
the saturation is increased, but typically, the image
becomes over-saturated. However, due to the low color
contrast of the low power display, the original image
appears to be de-saturated, and therefore the increased
saturation does not cause an over-saturation effect. This
algorithm is illustrated in Fig. 3.

Another useful algorithm is a componentwise
histogram stretching algorithm, which stretches the
dynamic range of each color component of the image. After
stretching, the dynamics of the image signal are
effectively utilized. Typical drawbacks are over-colored

image, resulting in contouring. It has proven that due to
the low dynamics of the above-mentioned low-power
displays, the contouring remains below a disturbing
level, and the image does not appear to be over-colored.

5   This algorithm is illustrated in Fig. 4, where the
smaller hatched area represents the color gamut of the
original image, and the larger hatched area represents
the color gamut of the improved image.

Yet another useful algorithm is an unsharp masking

10  algorithm, wherein a high pass filtered version of the
image is added to the original image. This algorithm is
illustrated in Fig. 5, where a signal of the image is
shown to the upper left, a high pass filtered version of
the signal is shown to the upper right, and the sum

15  thereof is shown at the bottom of the figure. The
algorithm increases local contrast around edges.
Visibility and subjective sharpness of edges are
increased. This algorithm produces ringing artefacts
around edges, and it increases the visibility of noise.

20  However, due to a typical small pixel size of the low
power display, for example, the ringing does not become
disturbingly visible. Further, the visibility of noise is
not high, because the display have low contrast
capability. As regards the noise, in fact a small amount

25  of noise hides the possible contouring artefacts, which
are due to other algorithms or due to the properties of
the display.

These algorithms can be combined, i.e. the image
processing method can make use of a plurality of the

30  algorithms for improving the image to an optimal extent.

The display processor 17 determines the parameters
to be used by the image processing method from a
combination of properties of the image and the display.
More particularly, the image is analysed, and preferably

35  statistical properties are measured, for example by means
of histograms. As regards the display 11, at least some
properties are known to the display processor 17

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beforehand. Typically, information about the display
properties is read from the display unit 3, or stored in
the memory of the device, when the display unit is
installed into the device 1. In addition to the color
5    gamut and color contrast ratio mentioned above, also for
example the instantaneous brightness can be taken into
account. All these display properties are changing
dynamically, and in some cases the display properties can
be adjusted from time to time by the user, who has the
10   opportunity to input desired settings of the display.
These user-specific display settings are then performed
by means of the display adjustment unit 15, which, in
this embodiment, receives the data for the settings from
the micro controller 5. The micro controller 5, in turn,
15   has received them via a user interface 21.
        The display processor 17, at a predetermined
repetition rate, repeatedly evaluates the instantaneous
state of the display, i.e. the instantaneous properties
thereof, by obtaining that information from the display
20   adjustment unit 15. Then the display processor uses that
information in conjunction with information of the image
for determining new parameters for the image processing
and provides these parameters to the display processor,
which uses them when performing the image processing
25   method. Finally the image is readjusted. The repetition
rate can differ according to what is appropriate in a
specific application. However, a typical rate is the
highest possible, in which case the image improvement
method runs continuously in a loop.
30       In one embodiment, for every repetition of the image
improvement method, the image processing method is
applied to the original image. At least this applies for
those algorithms that use statistical computations. Thus,
in this embodiment, the original image as well as the
35   improved image are stored. On the other hand, in some
cases it is possible to readjust the most recently

improved image, although most often this distorts the
image in an undesired way.

In addition, or as an alternative, to the above-
described repetitive readjustment of the image, the
5    readjustment of the image is performed when the
circumstances are changed. In this case, the display
properties on which the image processing is based are
monitored by means of the image improvement unit, i.e. in
this embodiment the display processor 17. When a
10   significant change is detected in a display property the
image improvement processing is initiated, which often
results in a readjustment of the improved image in the
display memory 13.

Another factor to be considered when the image is
15   improved is the illumination of the display 11. The
amount of illumination has an effect on the available
contrast and color contrast, especially when the display
is reflective. The quality of the illumination is also
important. For example, the color of the illumination
20   affects the color gamut of the display 11. Thus, in this
embodiment, the micro controller 5 receives data from the
sensor 19 as to the amount and quality of the ambient
light. The micro controller 5 then provides the display
processor 17 with corresponding information, and the
25   display processor 17 combines said information with
knowledge of a possible contribution from the internal
light of the display. Also, the display processor
controls the switching of the internal light.

Yet another factor that can be considered is the
30   temperature. The temperature has an effect on the
operation of LCDs. More particularly, the contrast and
the color properties of the display are temperature
dependent.

When the display is transflective, the determination
35   of the parameters for the image processing algorithm is
preferably also based on the operation mode. In other
words, it is detected if the display is in the reflective

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mode or in the transmissive mode, since the operation mode has an effect on the color gamut.

Due to the simple methods of image improvement the display processor can be rather simple, which is an
5 advantage.

In another embodiment of the mobile device, as shown in Fig. 2, the display processor is omitted. The parts of the second embodiment that have a correspondence in the first embodiment are provided with corresponding
10 numerals, though provided with an accent. In this second embodiment the image improvement processing is performed by the micro controller 5'. Thus, the properties of the display 11' that are not static, and thus can not be predetermined, are transferred from the display unit 3'
15 to the micro controller 5'.